

STABLE ISOTOPE LASER SPECTROSCOPY

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Recent advances in semiconductor laser technology have produced a reliable lightweight device ideally suited for a spacecraft high resolution molecular spectrometer. Lead-salt tunable diode lasers (TDL) emit in several spectral modes, each with a very narrow linewidth of $\sim 0.0003 \text{ cm}^{-1}$. This spectral resolution is much narrower than typical Doppler broadened molecular linewidths in the mid-IR range. Thus, it is possible to detect individual rotational lines within the vibrational band and measure their intensity, which can be used to determine gas concentration. Moreover, at such high spectral resolution, problems of impurity gases interfering with the measurement can be eliminated. The narrow spectral lines of any impurity gas tend to lie between the narrow lines of the gas of interest. This represents a major advantage over the accepted gas chromatograph mass spectrometer (GCMS) technique for measuring gas concentrations and isotope ratios. The careful and extensive gas purification procedures required to remove impurities for reliable GCMS measurements will not be required for an IR laser gas analysis.

We are developing the infra-red laser gas analysis technique to measure stable isotopic ratios of gases such as CO_2 , CH_4 , N_2O and NH_3 . This will eventually lead to development of instruments capable of *in situ* isotopic measurements on planets such as Mars. The carbon ($^{12}\text{C}/^{13}\text{C}$) isotope ratio is indicative of the type of carbon fixation mechanisms (e.g., photosynthesis, respiration) in operation on a planet, while the nitrogen ($^{14}\text{N}/^{15}\text{N}$) isotope ratio can probably be used to date nitrogen-bearing Martian samples.

We have recently measured the absorbance ratio of two adjacent lines of CO_2 in the 2300 cm^{-1} (4.3 micron) region of the spectrum. The precision of the measurement is presently better than 1% and significant improvement is anticipated as we incorporate rapid sweep-integration techniques and computer controlled data acquisition capabilities.

In addition to application to a Mars Rover, this technique has potential use in many areas of interest to NASA, such as determination of pressure, temperature, and chemical reaction rates in a shock wave, monitoring the environment of a space station, and field equipment for ground truth studies of atmosphere-biosphere interactions.